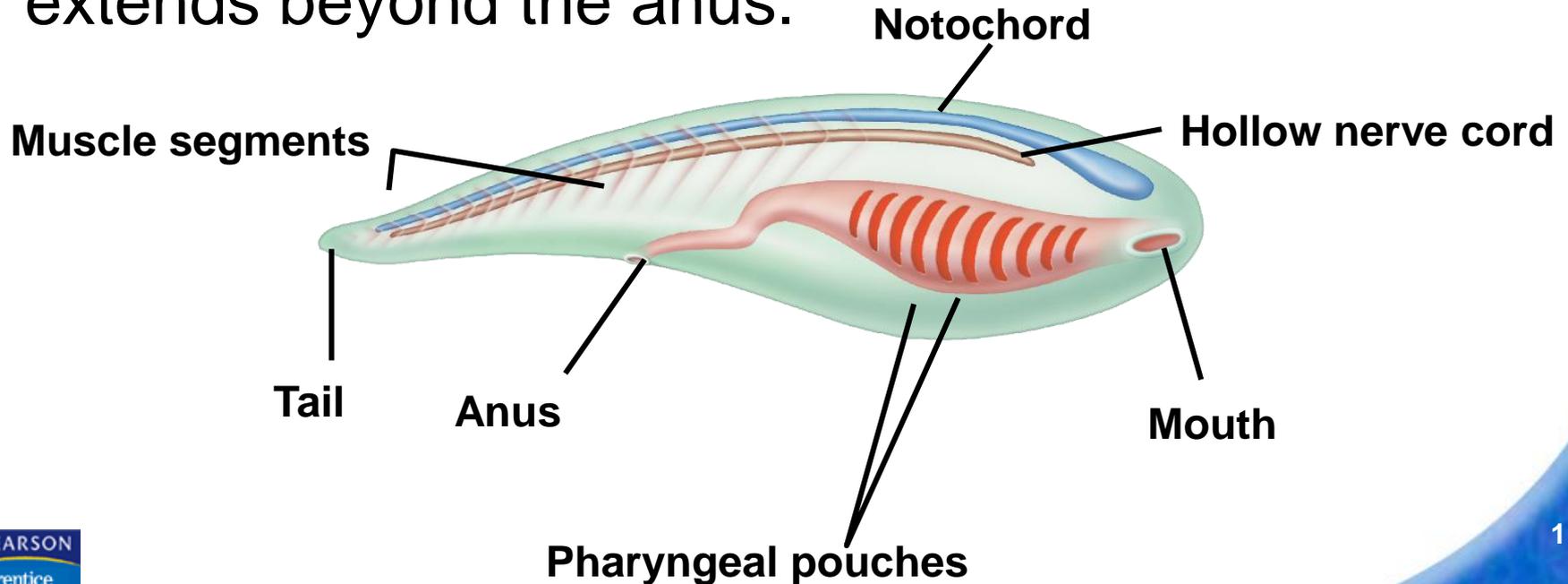


# What Is a Chordate?

Members of the phylum Chordata are called chordates.

A chordate is an animal that has, for at least some stage of its life, a dorsal, hollow nerve cord; a notochord; pharyngeal pouches; and a tail that extends beyond the anus.



- The **notochord** is a long supporting rod that runs through the body just below the nerve cord.
- Pharyngeal pouches** are paired structures in the throat (pharynx) region.
- The tail can contain bone and muscle and is used for swimming by many aquatic species.

### **Most Chordates Are Vertebrates**

- About 96 percent of all chordate species are vertebrates.

Most vertebrates have a vertebral column, or backbone.

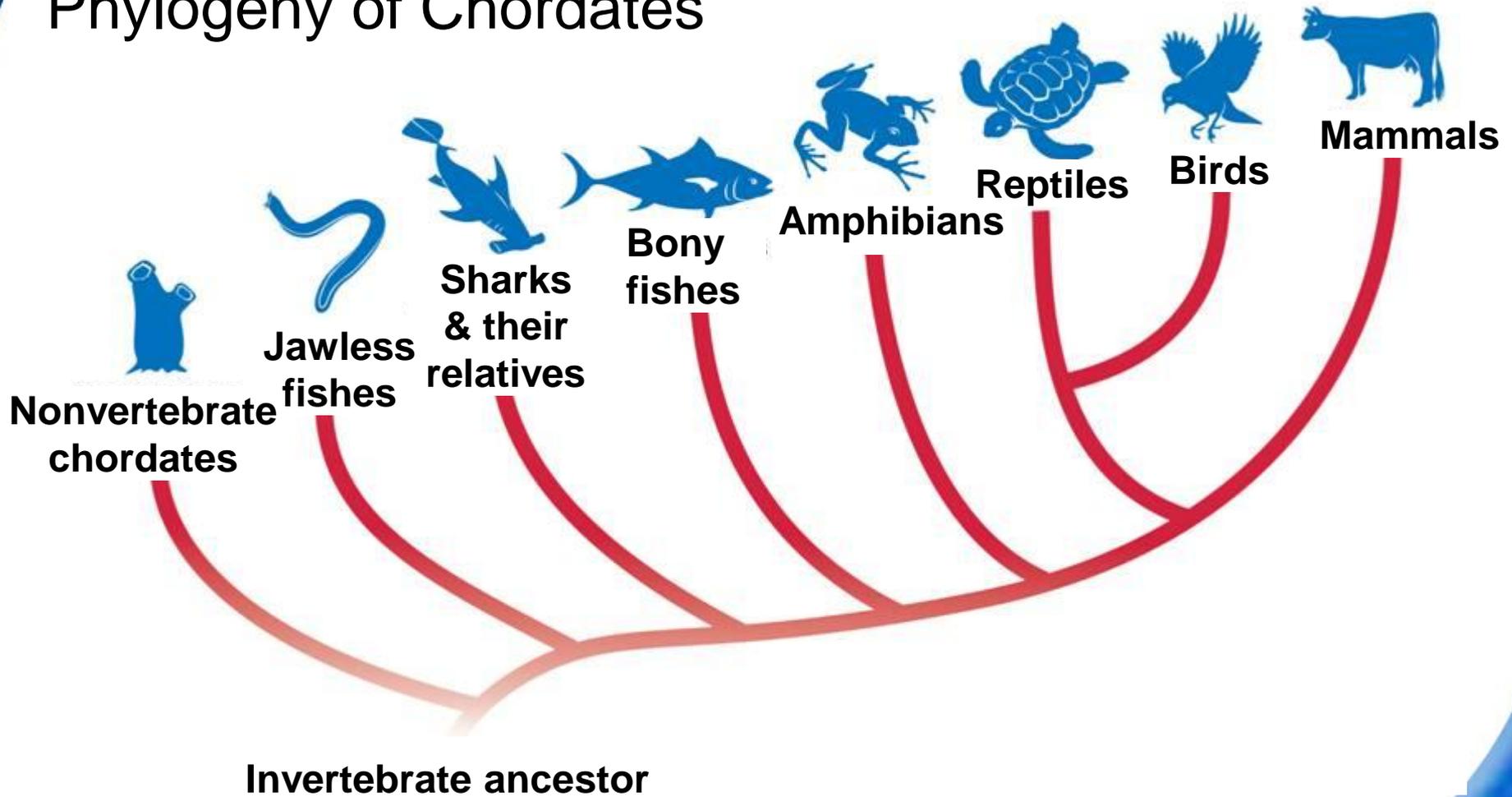
In vertebrates, the dorsal, hollow nerve cord is called the spinal cord.

As a vertebrate embryo develops, the front end of the spinal cord grows into a brain.

The backbone is made of individual segments called vertebrae.

In addition to support, vertebrae enclose and protect the spinal cord.

# Phylogeny of Chordates



# Nonvertebrate Chordates

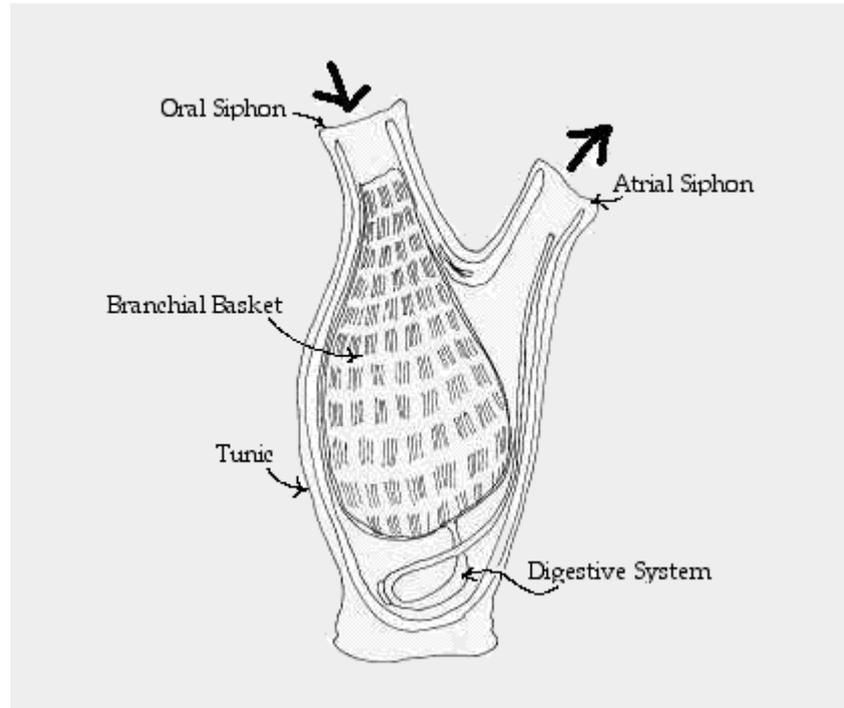
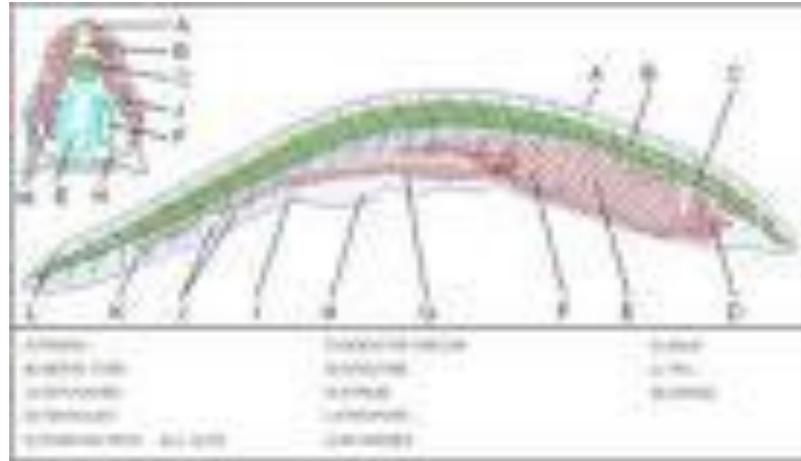


The two groups of nonvertebrate chordates are tunicates and lancelets.

Similarities in anatomy and embryological development indicate that vertebrates and nonvertebrate chordates evolved from a common ancestor.

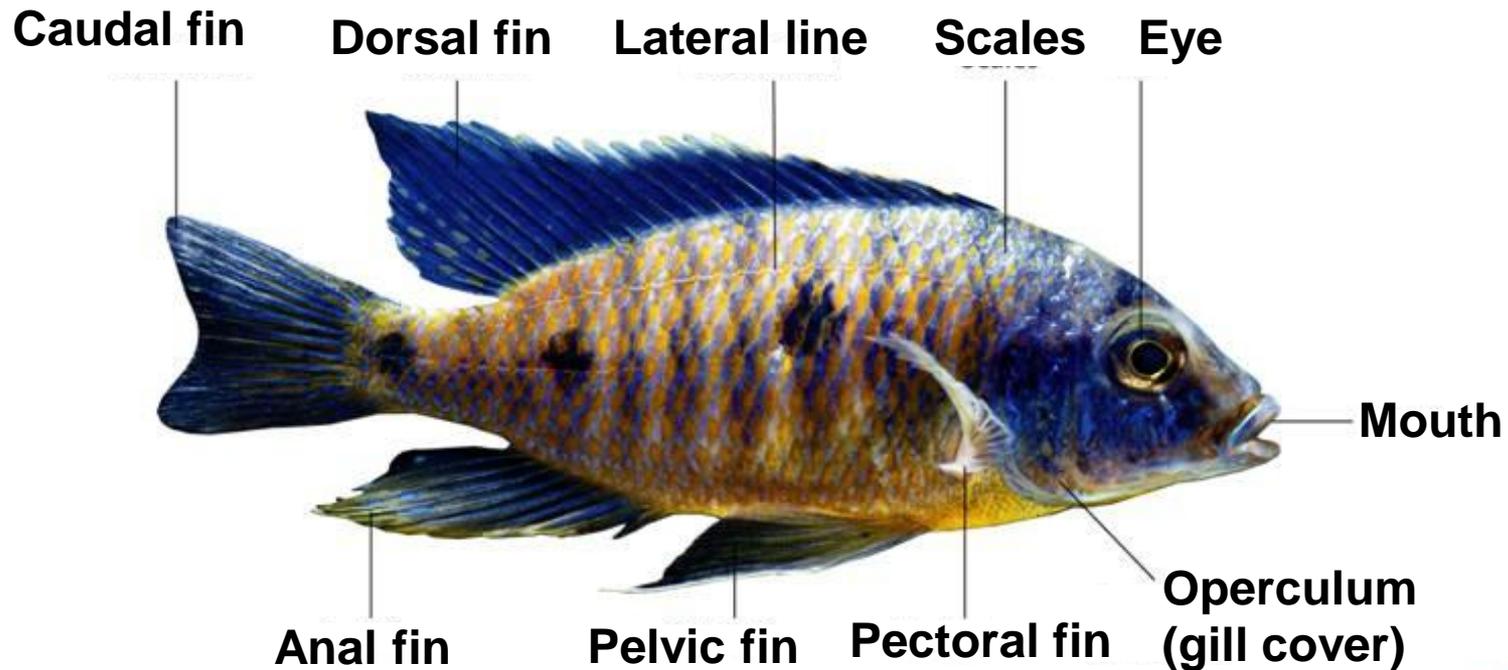
Both tunicates and lancelets are soft-bodied marine organisms.

# 30-1 The Chordates



## What Is a Fish?

Fishes are aquatic vertebrates. Most fishes have paired fins, scales, and gills.



## Form and Function in Fishes

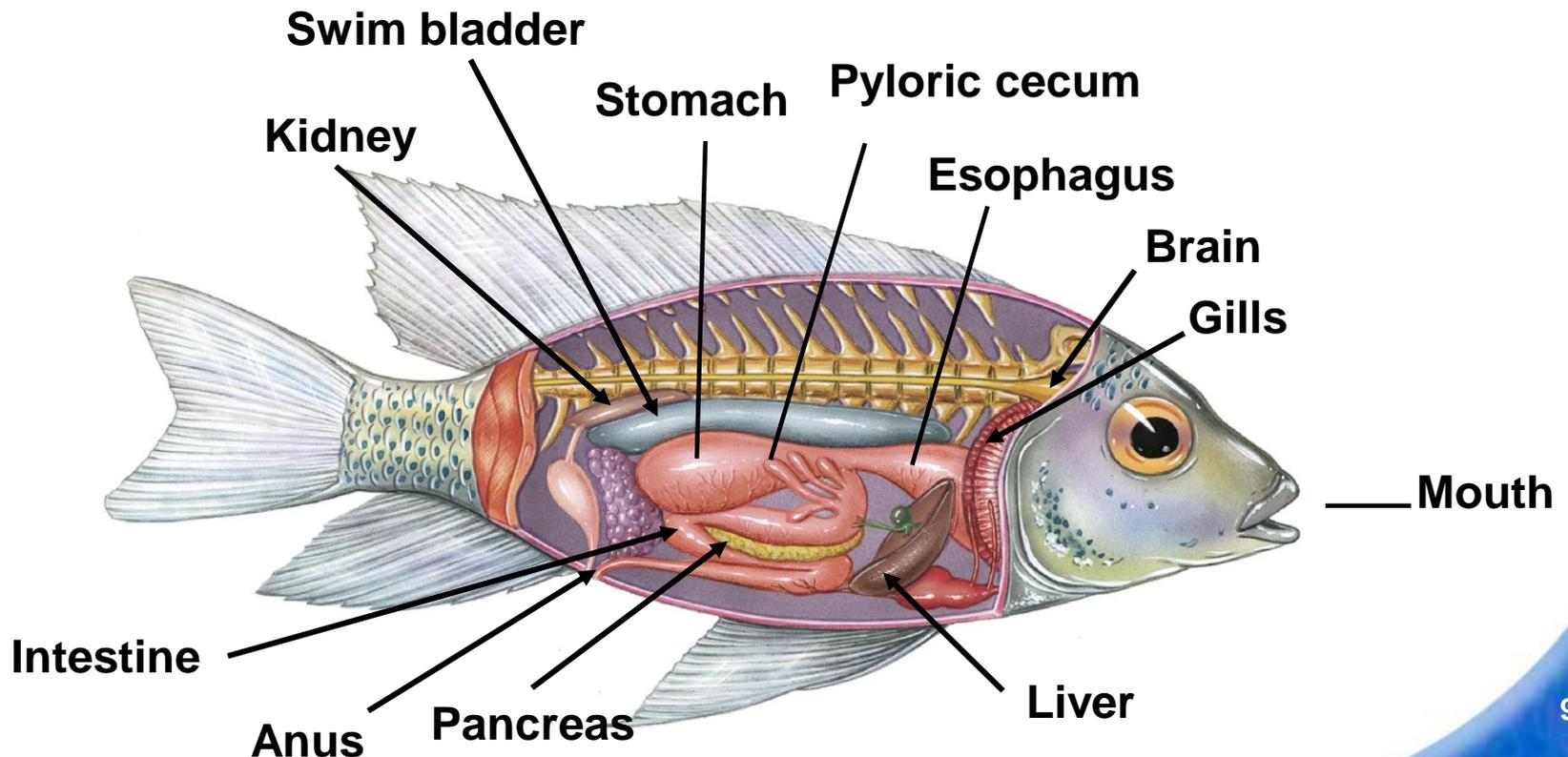
Adaptations to aquatic life include various modes of feeding, specialized structures for gas exchange, and paired fins for locomotion.

### Feeding

- Every mode of feeding is seen in fishes.
- A single fish may exhibit several modes of feeding, depending on the type of food available.

Food passes through the mouth and esophagus, into the stomach.

In the stomach, the food is partially broken down.



In many fishes, the food is further processed in fingerlike pouches called **pyloric ceca**.

The pyloric ceca secretes digestive enzymes and absorbs nutrients from the digested food.

The **liver** and **pancreas** add enzymes and other digestive chemicals to the food as it moves through the digestive tract.

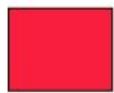
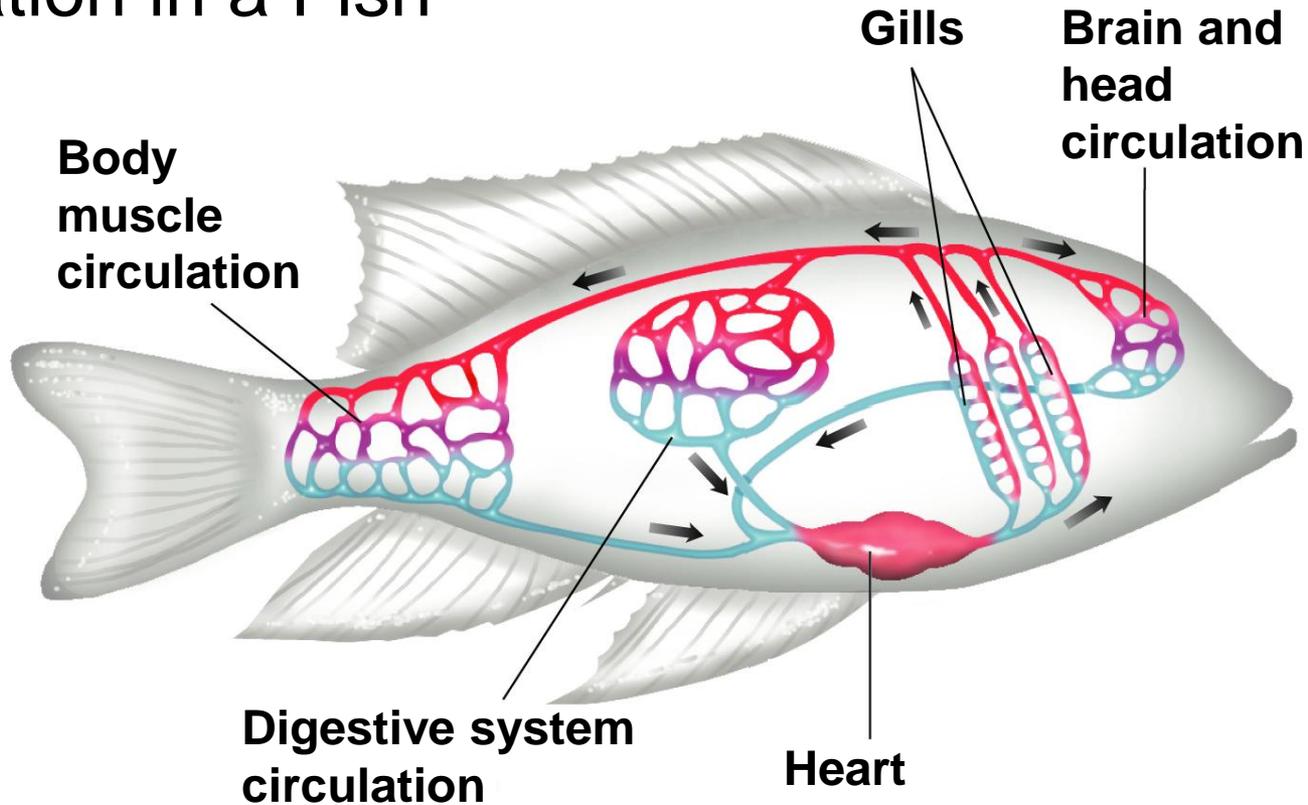
The **intestine** completes the process of digestion and nutrient absorption.

Undigested material is eliminated through the **anus**.

## Respiration

- Most fishes exchange gases using gills located on either side of the pharynx.
- Fishes use their gills to exchange gases by pulling oxygen-rich water in through their mouths, pumping it over their gill filaments, and pushing oxygen-poor water out through openings in the sides of the pharynx.

## Circulation in a Fish



Blood vessels carrying oxygen-rich blood



Blood vessels carrying oxygen-poor blood

## Circulation

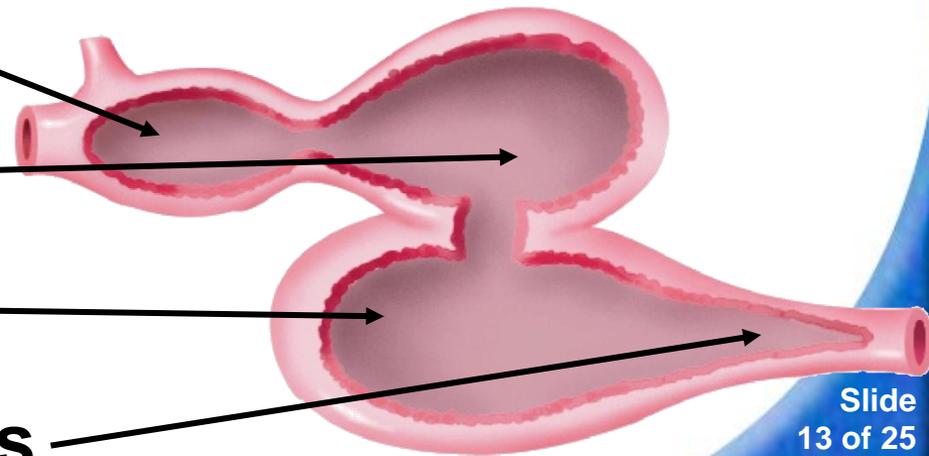
- Fishes have closed circulatory systems with a heart that pumps blood around the body in a single loop from the heart to the gills, from the gills to the rest of the body, and then back to the heart.
- In most fishes, the heart has four parts:

**the sinus venosus**

**the atrium**

**the ventricle**

**the bulbus arteriosis**



## Excretion

- Fishes eliminate nitrogenous wastes in the form of ammonia.
- Some wastes diffuse through the gills into the surrounding water.

Others wastes are removed by kidneys.

The kidneys of marine fishes concentrate wastes and return water to the body.

The kidneys of freshwater fishes pump out dilute urine.

## Response

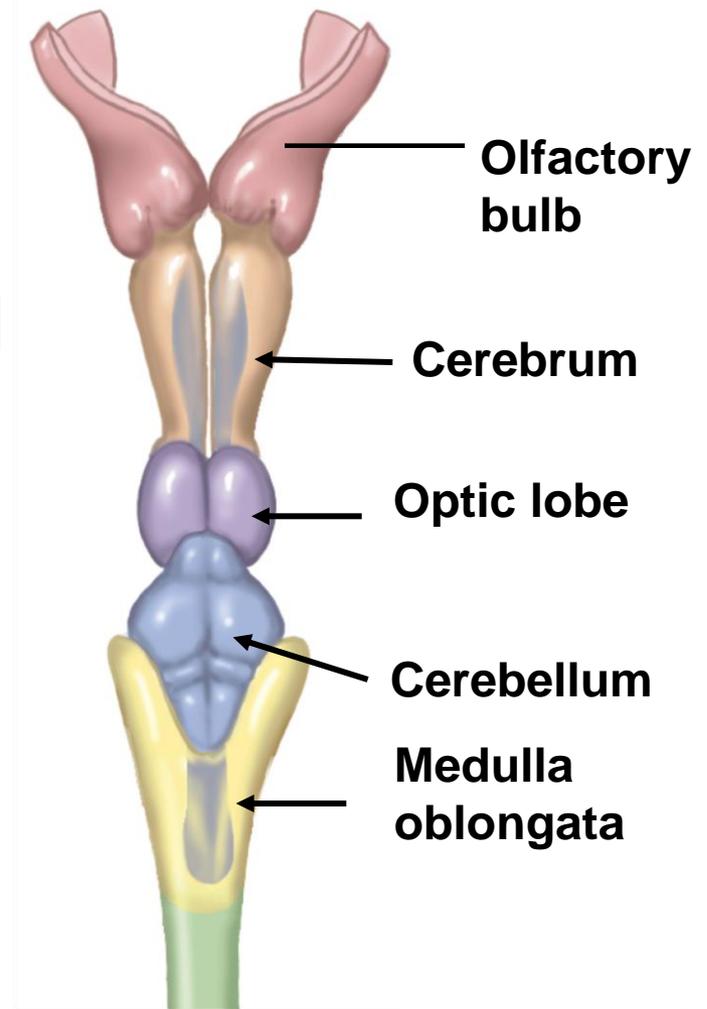
- Fishes have well-developed nervous systems organized around a brain.

The olfactory bulbs are involved with the sense of smell, or olfaction.

In most vertebrates, the **cerebrum** is responsible for all the voluntary activities of the body.

In fishes, however, the cerebrum primarily processes the sense of smell.

The optic lobes process information from the eyes.



The **cerebellum** coordinates body movements.

The medulla oblongata controls the functioning of many internal organs.

Almost all fishes that are active in daylight have well-developed eyes and color vision.

Many fishes have extraordinary senses of taste and smell.

Most fishes have ears but may not hear sounds well.

Fishes use the **lateral line system** to sense the motion of other fishes or prey swimming nearby.

Some fishes can detect low levels of electric current.

Many bony fishes have an internal, gas-filled organ called a **swim bladder** that adjusts their buoyancy.

## Movement

- Most fishes move by contracting paired sets of muscles on either side of the backbone.
- A series of S-shaped curves move down the fish's body.

- The force and the action of the fins propels the fish forward.
- The fins of fishes are used to keep on course and adjust direction.

## Reproduction

- The eggs of fishes are fertilized either externally or internally, depending on the species.
- Fishes whose embryos in the eggs develop and hatch outside the mother's body are **oviparous**.
- The embryos of oviparous fishes obtain food from the yolk in the egg.

In **ovoviviparous** species, the eggs stay in the mother's body after internal fertilization.

Each embryo develops inside its egg, using the yolk for nourishment.

The young are “born alive” like most mammals.

In **viviparous** animals, the embryos stay in the mother's body after internal fertilization.

These embryos obtain the substances they need from the mother's body (not from material in an egg).

The young of viviparous species are “born alive.”

## Lamprey



### Groups of Fishes

All living fishes can be classified into three groups: jawless fishes, cartilaginous fishes, and bony fishes.

### Jawless Fishes - class Agnatha

- Jawless fishes have no true teeth or jaws.
- Their skeletons are made of fibers and cartilage.
- They lack vertebrae, and keep their notochords as adults.
- Modern jawless fishes are divided into two classes: lampreys and hagfishes.



## Sharks and Their Relatives

- The class Chondrichthyes contains sharks, rays, skates, sawfishes, and chimaeras.
- The skeletons of these fishes are built entirely of cartilage.
- Many sharks have thousands of teeth arranged in several rows.
- Most species of sharks do not attack people.

Some skates and rays feed on bottom-dwelling invertebrates.

The largest rays eat floating plankton.

Skates and rays glide through the sea with their large, winglike pectoral fins.

Many skates and rays cover themselves with sand and rest on the ocean floor.



## Bony Fishes

- Class Osteichthyes.
- Their skeletons are made of bone.
- Almost all living bony fishes are ray-finned fishes.
- “Ray-finned” refers to the slender bony spines, or rays, that are connected by a thin layer of skin to form the fins.

Only seven living species of bony fishes are not classified as ray-finned fishes.

These are the lobe-finned fishes, a subclass that includes lungfishes and the coelacanth.

The fleshy fins of lobe-finned fishes have support bones.

Some of these bones are jointed. Some fishes spend most of their lives in the ocean but migrate to fresh water to breed. These fish are called anadromous.

Ex) Salmon

# 30-3 Amphibians

## Class - Amphibia

What Is an Amphibian?

An amphibian is a vertebrate that, with some exceptions:

- **lives in water as a larva and on land as an adult**
- **breathes with lungs as an adult**
- **has moist skin that contains mucous glands**
- **lacks scales and claws**

## Evolution of Amphibians

- The first amphibians appeared in the late Devonian Period, about 360 million years ago.
- The transition from water to land required that the terrestrial vertebrates had to:

**breathe air,**

**protect themselves and their eggs from drying out, and**

**support themselves against the pull of gravity.**

Early amphibians evolved several adaptations that helped them live at least part of their lives out of water.

Bones in the limbs and limb girdles of amphibians became stronger, permitting more efficient movement.

Lungs and breathing tubes enabled amphibians to breathe air.

The sternum formed a bony shield to support and protect internal organs, especially the lungs.

In many adult amphibians, the internal surfaces of the lungs are richly supplied with blood vessels and folds that increase surface area.

## Form and Function in Amphibians

- The class Amphibia is relatively small and diverse.

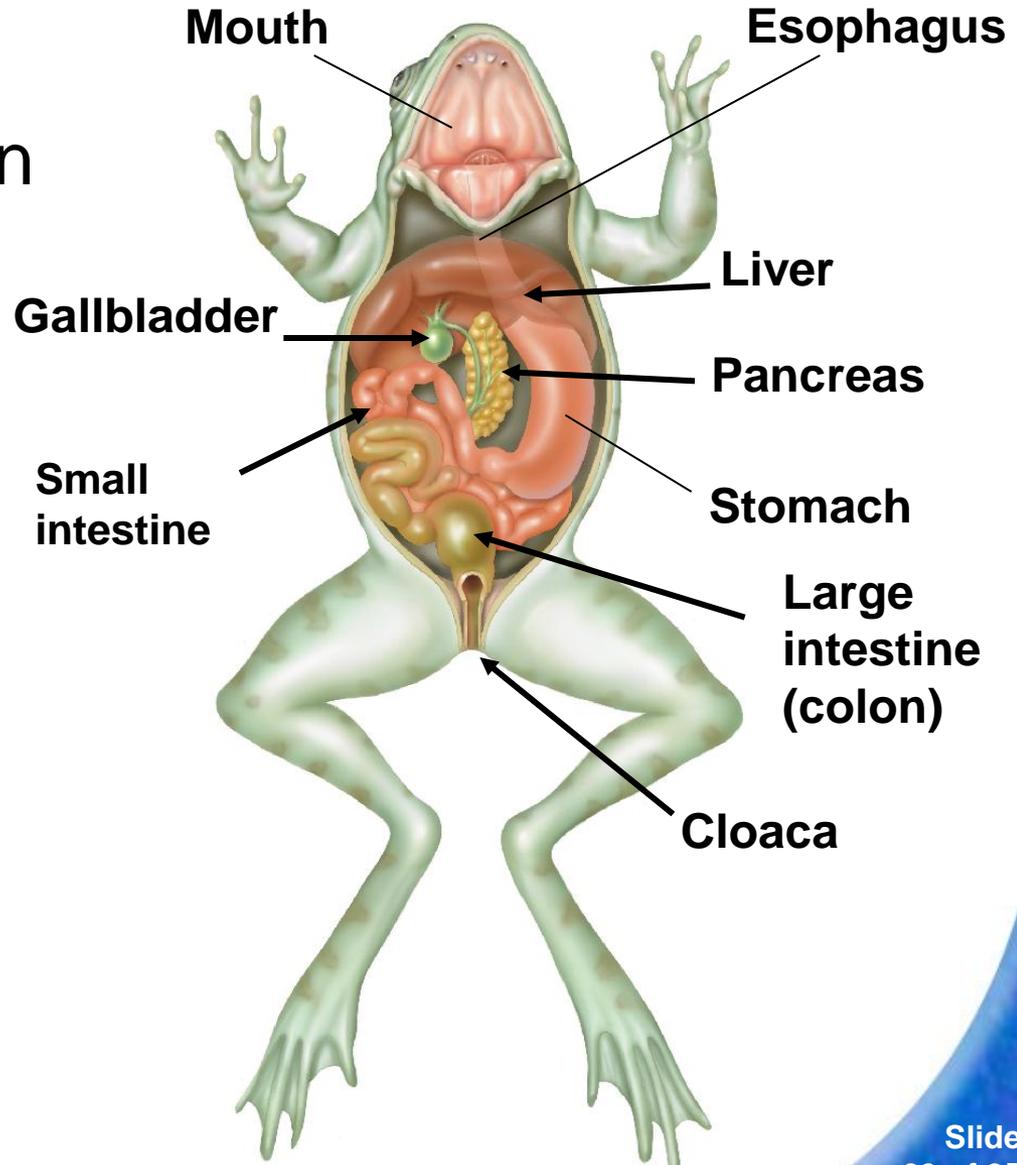
### Feeding

- Tadpoles are typically filter feeders or herbivores that graze on algae.
- Their intestines help break down hard-to-digest plant material and are usually filled with food.
- The feeding apparatus and digestive tract of adults are meat-eating structures.

In a frog's digestive system, food slides down the esophagus into the stomach.

The breakdown of food begins in the stomach and continues in the small intestine.

The liver, pancreas, and gallbladder secrete substances that aid in digestion.



At the end of the large intestine is a muscular cavity called the **cloaca**, through which digestive wastes, urine, and eggs or sperm leave the body.

## Respiration

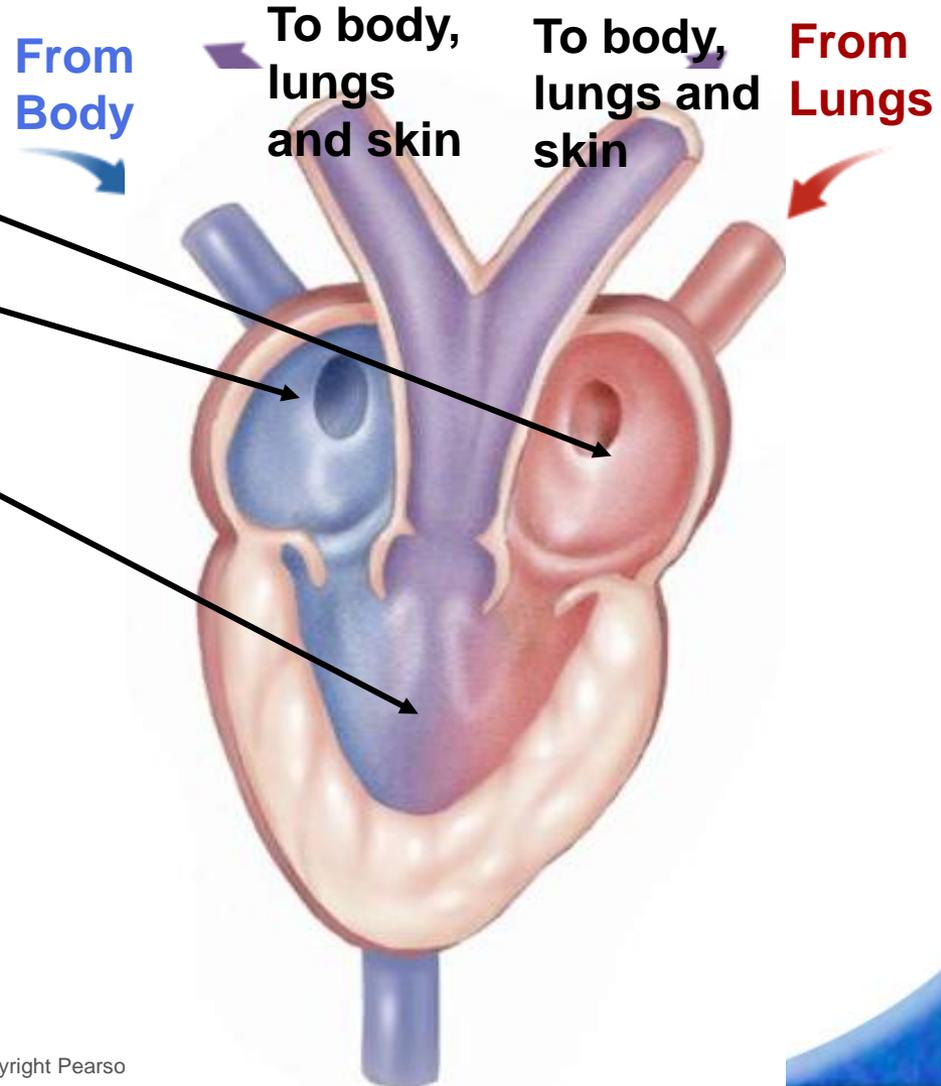
- In most larval amphibians, gas exchange occurs through the skin and the gills.
- Adult amphibians typically respire using lungs, but some gas exchange occurs through the skin and the lining of the mouth.

## Circulation

- In frogs and other adult amphibians, the circulatory system forms a double loop.
- The first loop carries oxygen-poor blood from the heart to the lungs and skin, and takes oxygen-rich blood from the lungs and skin back to the heart.
- The second loop transports oxygen-rich blood from the heart to the rest of the body, and carries oxygen-poor blood from the body back to the heart.

The amphibian heart has three separate chambers:

- left atrium
- right atrium
- ventricle



## Excretion

- Amphibians have kidneys that filter wastes from the blood.
- Urine travels through tubes called ureters into the cloaca.
- Urine is then passed directly to the outside, or temporarily stored in a small urinary bladder just above the cloaca.

## Reproduction

- In most species of amphibians, the female lays eggs in water, then the male fertilizes them externally.
- In a few species, including most salamanders, eggs are fertilized internally.
- After fertilization, frog eggs are encased in a sticky, transparent jelly.

## Movement

- Amphibian larvae move by wiggling their bodies and using a flattened tail for propulsion.
- Adult salamanders walk or run.
- Frogs and toads, have well-developed hind limbs that enable them to jump long distances.

## Response

- Amphibians have well-developed nervous and sensory systems.

- An amphibian's eyes are protected from damage and kept moist by a transparent **nictitating membrane**.
- This membrane is located inside the regular eyelid and can be closed over the eye.
- Amphibians hear through **tympanic membranes**, or eardrums, located on each side of the head.
- Many amphibian larvae and adults have lateral line systems that detect water movement.

## Groups of Amphibians

The three groups of amphibians alive today are:

- **Salamanders**



- **frogs and toads**



- **caecilians**



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